150 HP Variable Speed Drive Specification

1.0 VARIABLE SPEED DRIVE SYSTEM (VSDS) FOR 1000 GPM FIRE PUMPS

1.1 General

This specification establishes requirements for a Variable Speed Drive System (VSDS). This VSDS will be used to control a 150HP Fire Pump installed on DDG Class Ships.

The goal of this specification is to take a commercial off the shelf variable speed drive and develop and build a VSDS design that meets military technical requirements as set forth in this specification and is as small as possible. As part of the deliverables, an EMI test report will be provided by the offeror demonstrating that the VSDS design meets Mil-Std-461E for surface ships. In addition, a test report shall be provided by the offeror demonstrating that the VSDS design is capable of operating within the parameters established by Mil-Std-1399 300A.

The VSDS shall consist of one enclosure which shall contain all electrical and mechanical components required for control of the motor and pump. The system will have two modes of operation. In Automatic Mode the VSD's PID controller will be used to maintain the desired pressure setpoint. Process feedback and setpoints will be from separate 4-20mA signals. In Manual Mode the keypad will set the drive speed, and pressure will be maintained manually.

The load consists of an induction motor directly coupled to a centrifugal pump. The motor is constructed according to MIL-M-17060E. The motor can have either Class B or Class F insulation and is rated for 150 horsepower, 3600 RPM, at 50^0C. The pump load will range from 67 horsepower at 2800 RPM to 134 horsepower at 3580 RPM.

The VSDS is to use an active front end and is to be air cooled and must be able to operate in an ambient temperature of 50^0C.

2. APPLICABLE DOCUMENTS.

2.1 General. The documents listed in this section are specified in sections 3 and 4 of this specification. This section does not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of the documents cited in sections 3 and 4 of this specification.

2.2 Government Documents.

2.2 Government Documents.

2.2.1 Specifications, Standards and Handbooks. The following specifications and standards form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DoDISS) and supplements thereto, cited in the solicitation.

SPECIFICATIONS and STANDARDS

MIL-STD-889 1993	Dissimilar Metals
MIL-STD-810	Environmental Engineering Considerations and Laboratory Tests
MIL-DTL-2212 1997	Contactors and Controllers, Electric Motor AC or DC and Associated Switching Devices
MIL-STD-461 1999	Requirements for the Control of Electromagnetic Interference Emissions and Susceptibility
MIL-STD-882 2000	System Safety Program Requirements
MIL-STD-167-1 1987	Mechanical Vibrations of Shipboard Equipment (Type I – Environmental and Type II – Internally Excited)
MIL-STD-901 1989	Requirements for Shock Tests HI (High Impact); Shipboard Machinery, Equipment, and Systems
MIL-E-917 1993	Electric Power Equipment, Basic Requirements
MIL-STD-1310 1996	Standard Practice for Shipboard Bonding, Grounding and Other Techniques for Electromagnetic Compatibility and Safety
MIL-STD-1399, Section 300 1992	Interface Standard for Shipboard Systems, Electric Power, Alternating Current (Metric)
DOD-STD-1399, Section 301 1986	Interface Standard for Shipboard Systems, Ship Motion and Attitude (Metric)
MIL-STD-1472 1999	Human Engineering Design Criteria for Military Systems, Equipment and Facilities
MIL-E-2036 2001	Enclosures for Electric and Electronic Equipment
MIL-DTL-24643 2002	General Specification for Cables and Cords, Electric, Low Smoke, For Shipboard Use
MIL-DTL-15090 1996	Enamel, Equipment, Light Gray, (Navy Formula 111)
FED-STD-595/26307 1994	Gray, Semi-gloss

(Unless otherwise indicated, copies of the above specifications, standards and handbooks are available from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094 [www.dsp.dla.mil]).

2.3 **Non-government Publications.** The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents, which are DoD-adopted, are those listed in the issue of the DoDISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DoDISS are the issues of the documents cited in the solicitation (please see 6.2).

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION

NEMA 250 - 1997 Enclosures for Electrical Equipment (1000 Volts Maximum)

(Application for copies should be addressed to the National Electrical Manufacturers Association, 1300 North 17th Street, Suite 1847, Rosslyn, Virginia 22209 [www.nema.org].)

2.4 Order of Precedence. In the event of a conflict between the text of this document and the references cited herein (except for related associated specifications or specification sheets), the text of this document shall take precedence. Nothing in this document however, supersedes applicable laws or regulations unless a specific exemption shall have been obtained.

3. VSD SYSTEM GENERAL REQUIREMENTS

3.1 Mechanical Characteristics

3.1.1 Enclosure Requirements. The VSDS system components shall be mounted in a single enclosure not greater than 50,000in^3 and shall have a footprint no larger than 35" width by 24" depth, not including shock mounts. Enclosure type shall be NEMA3R as defined in MIL-E-2036 and NEMA 250-1997 and shall be designed to be reinforced and strengthened to reduce or eliminate flexing at a low natural frequency. The enclosure shall meet shock requirements as defined in MIL-STD-901D and vibration requirements as defined in MIL-STD167/1. In addition, the enclosure will be electromagnetically sealed to meet MIL-STD-461E.

Provisions shall be made for deck mounting. Sway braces and shock mounts are to be provided with the enclosure.

An unpainted knockout panel, which is corrosion resistant and sealed electromagnetically, shall be provided at the designed point of entry of cables into and out of the enclosure.

Provisions for vertical hoisting of the VSDS shall be provided. If required, lifting fixtures shall be provided.

3.1.2 Component Mounting. All components shall be mounted to be able to withstand a rugged environment.

3.1.3 Label Plates. The device shall be identified with engraved label plates, mounted on the device.

3.1.4 Painting. The VSD system enclosure shall be painted Machinery Gray, in accordance with FED-STD-595/26307. The paint scheme selected by the manufacturer shall be compatible with shipboard maintenance practices as detailed in NAVSHIPS Technical Manual, Chapter 631 and for use with Navy Formula 111 as formulated in accordance with MIL-DTL-15090.

Note: This is an interface requirement. The manufacturer may select any coating scheme that matches color 26307 and is compatible with the maintenance practices in NSTM 631 and the shipboard use of Navy paint formula 111.

3.1.5 Recycled, Recovered or Environmentally Preferable Materials. Recycled, recovered or environmentally preferable materials should be used to the maximum extent possible provided that the materials shall meet or exceed the operational and maintenance requirements, and promote economically advantageous life cycle costs. The terms "recycled, recovered or environmentally preferable materials" means materials that have been collected or recovered from solid waste and reprocessed to become a source of raw materials, as opposed to virgin raw materials. None of the above shall be interpreted to mean that the use of used or rebuilt products is allowed under this specification unless otherwise expressly stipulated.

3.1.6 Hazardous Materials. Materials for use in the construction of VSD's shall have no effect on the health of personnel when the materials are used for their intended purpose. Regardless of other requirements, materials and parts containing asbestos, cadmium, lithium, mercury or radioactive material shall not be used.

3.1.7 Fasteners. Materials for all bolts, nuts, studs, screws and similar fasteners shall be corrosion-resistant passivated or of a material rendered resistant to corrosion. Sheet metal screws shall not be used. Galling shall be prevented. Tapped holes shall be reinforced where shearing of thread can occur.

3.1.8 Rubber or Synthetic Rubber Material. Rubber or synthetic rubber material shall not deteriorate due to contact with any fluid used for operation or maintenance of the VSD system.

3.1.9 Metals. Metals shall be of corrosion-resistant type or suitably treated to resist corrosion due to fuels, salt, spray or atmospheric conditions likely to be met in storage or normal service.

3.1.10 Dissimilar Metals. Unless suitably protected against electrolytic corrosion, dissimilar metals shall not be used in contact with each other. Dissimilar metals are defined in MIL-STD-889.

3.1.11 Assembly. The VSD system shall be provided as a kit, which shall incorporate all materials required for one complete installation. Kits shall be individually packaged. Cable or conduit termination and mounting hardware shall be provided separately by the installing activity.

3.1.12 Identification Plates. The VSD system shall be identified with a label plate that shall include the manufacturer's name, address and phone number, VSD device model number, VSD device serial number, and the VSD device rated voltage, current and horsepower. It is understood that more than one label may be utilized to provide all information specified above.

3.2 Environmental Conditions.

3.2.1 Location. The VSD system shall be installed in a sheltered location aboard ship; as such, the device will be protected from the external environment. The sheltered environment may be either controlled or uncontrolled.

3.2.2 Ambient Temperature. The VSD system shall withstand storage temperatures of -25 to 65 degrees Celsius (–4 to 149 degrees Fahrenheit) and ambient operating temperatures of -10 to 50 degrees Celsius (+14 to 122 degrees Fahrenheit) without any derating of the device. The VSD system shall meet Method 501 of MIL-STD-810.

3.2.3 Cooling. The VSD system shall be air cooled.

3.2.4 Relative Humidity. The VSD system shall operate in a relative humidity of 0 to 100 percent (non-condensing). The VSD system meet Method 507 of MIL-STD-810.

3.2.5 Inclination. The VSD system shall operate at any inclination.

3.2.6 Ship Motion and Attitude. The VSD system shall be fully operational for the ship motion and attitude conditions set forth in DOD-STD-1399, Section 301.

3.2.7 Shock. The VSD system shall meet Type A shock requirements as defined in MIL-S-901. Shock mounts and sway braces shall be specified and mounted on enclosure.

3.2.8 Vibration. The VSD system shall meet Type I vibration requirements of MIL-STD-167-1.

3.3 Safety.

3.3.1 Hazards. Hazards to VSD system equipment and personnel shall be minimized by the application of system safety principles in accordance with MIL-STD-882. Warnings and other markings should be applied as necessary to aid personnel in avoiding potential hazards or minimize to maintenance, servicing or operational problems.

3.4 Human Engineering.

3.4.1 Ergonomics. The VSD system shall be arranged so as to achieve safe, reliable, and effective performance by the operator and maintenance personnel and to optimize personnel skill requirements. MIL-STD-1472 may be used as a guide in applying human engineering design criteria for the VSD system.

3.5 Electrical Characteristics.

3.5.1 Input Power Characteristics. Electrical power for the VSD system shall be provided by the Ship Service Power System. The VSD system must be able to maintain output as defined in this specification when supplied from an ungrounded power system with characteristics as defined by MIL-STD-1399 Section 300 Type 1 power. The VSD system must be capable of maintaining output as defined in this specification with a single accidental phase to ground fault on an ungrounded system indefinitely.

3.5.2 Power Quality. The VSD system shall be designed to maintain voltage and current power quality on the input power cable to the VSD in accordance with MIL-STD-1399 Section 300 Type 1 power for all operating conditions of the VSD system and load, except starting.

3.5.3 Bonding and Grounding. The VSD system shall be bonded and grounded in accordance with MIL-STD-1310.

3.5.4 Interface Requirements. The VSD system shall be able to operate within the parameters established by Mil-Std-1399 Section 300 Table 1 for Type 1 power.

3.5.5 Electromagnetic Interference Requirements. The VSD system shall meet electromagnetic interference requirements in accordance with MIL-STD-461E. All tests that are applicable for surface ships as defined in Table V of MIL-STD-461E are to be completed in addition to CE101.

3.5.6 Automatic Transfer of Power. The VSD system shall be able to reset automatically without damage to the VSD when power is switched from normal to alternate power in a time frame of 600 milliseconds.

3.6 Variable Speed Drive Characteristics.

3.6.1 Variable Speed Drive Sizing. The power rating of the VSD shall be sized to the power rating of the motor. The VSD shall be capable of smoothly controlling the motor output speed from standstill to rated speed. The VSD shall also be capable of continuously operating the motor at any speed and torque within the ranges described and under the environmental conditions as described in this document.

3.6.2 VSD Control Functions. The VSD will provide the user configurable scalar, flux vector or sensorless vector control and include the following features:

1. Drive efficiency rating of at least 95 percent at full load.
2. Microprocessor based adjustable frequency inverter
3. Automatic voltage adjustment within power range.
4. Digital user interface panel with full function LED display for operating parameter control and status. (to include a minimum of the parameters delineated in section 3.6.5)

5. Comprehensive warning and fault protection message processing and display. (to include a minimum of the parameters delineated in section 3.6.6)
6. PC Interface

The VSD shall have provisions for remote/local control and programming of motor operation and adjustable parameters. It shall provide circuits for analog control and sensor inputs, PID process control and PC interface. The keypad will serve as a means to configure controller parameters.

3.6.3 VSD Programming. The VSD shall be fully programmable via the front panel or remote PC for adjusting parameters and setting speed and torque profiles. A digital LED display shall be provided for viewing operational parameters.

3.6.4 VSD Parameter Adjustments. At a minimum, the VSD shall be user programmable for the following functions using the command center or PC interface:

1. Access authorization to controller functions (password protection)
2. Motor operating modes
3. Minimum and maximum switching frequency
4. Minimum and maximum motor speed
5. Motor overload current
6. Programmable torque and speed profile
7. Acceleration/Deceleration time
8. Torque/Current limiting

3.6.5 VSD Standard Displays. The VSD keypad shall use high intensity digital LED displays for viewing operational parameters and shall be clearly visible in a dark or bright environment. At a minimum, the following displays shall be user selectable from the keypad:

1. DC Link Voltage
2. Motor torque
3. Motor speed
4. Output frequency
5. Output current
6. Output torque
7. Output voltage
8. Output power

3.6.6 Protective Controls and Status Indicators. The following controls and indicators (menu selectable) shall be available at a minimum as standard with the VSD. Additional protective features may be required.

1. Input overcurrent / undercurrent
2. Input overvoltage / undervoltage
3. Overfrequency / underfrequency
4. Output phase loss

5. Adjustable output current limit
6. Ground fault short circuit

3.6.7 PC Interface. The VSD shall be fitted with a separate communications port designed for connection to a personal computer (PC). The CONTRACTOR shall provide a Windows based software tool for commissioning and maintenance purposes. The software tool shall be capable of adjusting parameters, displaying actual values and controlling the VSD in lieu of the keypad.

3.7 Cabling.

3.7.1 Cable Types. Cables connected to and internal to the VSD system shall meet requirements as specified in MIL-DTL-24643.

3.8 VSD System Operation.

3.8.1 Service Life. The design service life of the VSD system for the specified operating environment shall be twenty (20) years.

3.8.2 Duty Cycle. The VSD system shall be capable of continuous operation (24 hours a day, 7 days a week).

3.9 Reliablility/Maintainability.

3.9.1 Reliability. The VSD system shall be designed for a Mean Time Between Failure of at least 10,000 hours.

4.0 Controls/Indicators for VSD System

4.1 Drive System I/O Interface Description

At a minimum the drive shall be wired for and capable of supporting the following I/O:

1. Remote START/STOP Control Inputs via external dry Normally Open (NO) start pushbutton and Normally Closed (NC) stop pushbutton wired in series.
2. Dedicated 110VAC relays for remote START/STOP of motor
3. Local START/STOP Control Inputs via NO start pushbutton and NC stop pushbutton wired in series.
4. Local and Remote Motor Running Indicator LED (Green). Remote indication via set of NO internal contacts rated for 24VDC or 115VAC.
5. Local or Remote Operation Selector Switch
6. Process Feedback input 4-20mA.
7. Local Power available indicator LED (White)
8. Local and Remote Drive Fault or Motor Overload Indicator LED (Red). Remote indication via set of NO internal contacts rated for 24VDC or 115VAC.

9. Suction and Discharge valve interlocks via external NO position switch contacts.
10. Local and Remote Fire Pump Ready Indicator LED (Green), (power available, suction and discharge valve open). Remote indication via set of NO internal contacts rated for 24VDC or 115VAC.
11. Local Suction Valve Indicator LED (White).
12. 110VAC power supply for motor thermistor monitor.
13. Motor thermal protection interlock.
14. Door mounted socket for PC interface.
15. Door mounted keypad socket and mounting for set/maintenance use. Normal keypad location will be on the drive inside the enclosure.

4.2 Operator Devices to Be Door Mounted and Wired

The following devices are to be door mounted and integrated in the controls of the VSDS:

1. START – pushbutton
2. STOP – pushbutton
3. DRIVE FAULT RESET – pushbutton
4. MOTOR OVERLOAD RESET – pushbutton
5. POWER ON – indicator light / white
6. MOTOR RUNNING – indicator light / green
7. MOTOR OVERLOAD/DRIVE FAULT – indicator light / red
8. LOCAL/REMOTE OPERATION SELECTOR SWITCH
9. SUCTION VALVE OPEN – indicator light / white
10. READY – indicator light / white

4.3 Control Scheme

The control system for the VSDS is to include the control network logic as shown in Figure #1. There will be two modes of operation:

Mode 1: Manual Mode

1. Operation from keypad
2. SUCTION VALVE OPEN indicator light
3. READY indicator light
4. POWER ON indicator light
5. MOTOR RUNNING indicator light

Mode 2: Automatic Mode

1. PID Feedback
2. START/STOP control inputs from local/remote locations
3. SUCTION VALVE OPEN indicator light
4. READY indicator light
5. POWER ON indicator light
6. MOTOR RUNNING indicator light

5.0 Technical Documentation

5.1 Technical Documentation Requirements

The CONTRACTOR shall provide a clearly illustrated technical manual covered by item OOO4 describing the operation, maintenance and overhaul of the VSD System and its components. The technical manual shall include drawings that contain schematics and plan views and be of sufficient detail for use by personnel when installing, operating or maintaining the VSD System. An illustrated parts breakdown of all major components inside the VSD and part numbers shall be included. The technical manual shall be provided at the time of the VSD System delivery. The technical manual covering the VSD System equipment shall be self contained. The technical manual shall consider the entire system, not a series of individual components.

6.0 Testing Requirements

6.1 EMI Testing.

Prior to delivery of the VSD system, the offeror shall perform the EMI tests as specified in paragraph *3.5.5* hereof and submit an EMI test report covered by item OOO2.

6.2 Interface Requirement Testing.

Prior to delivery of the VSD system, the offeror shall perform Interface requirement tests to determine if the drive system operates and can operate within the parameters of MIL-STD- 1399 Section 300 Table 1 for Type 1 power and submit an Interface test report covered by item OOO3. If the Variable Speed Drive has already been tested to other requirements, such as UL, which are stricter than MIL-STD- 1399, waivers can be applied. Proper documentation must be presented, in order to make that determination.

7.0 Delivery Requirements

7.1 Test Reports.

The EMI Test Report and the Interface Requirements Test Report shall be delivered within *165* days after date of order. The Government will notify the Contractor of the approval, disapproval, or conditional approval of the Test Reports within 21 days after receipt.

7.2 Drive System and Technical Manual.

The 350HP Variable Speed Drive System and Technical Manual shall be delivered within 200 days after date of order.